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The Provision of Public Goods with Positive Group Interdependencies

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Abstract

This article examines the nature of human behavior in a nested social dilemma referred to as the Spillover Game. Players are divided into two groups with positive production interdependencies. Based on theoretically derived opportunistic, local, and global optima, our experimental results demonstrate the importance of in-group beneficiaries over global efficiency. We find that the observed behavior is primarily determined by an imperfect conditional cooperation that prioritizes local level feedback. Results stress the importance of building strong local level commitment to encourage the provision of public goods with positive externalities.

Keywords:
Public good; experiment; groups; Spillover Game; social dilemma
JEL-classification: H41; C72; C91; C92

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1. Introduction

"Imagine there's no countries. It isn't hard to do. Imagine no possessions. I wonder if you can."[1] Global public goods constitute a class of common goods available to all humankind. At the same time, the provision of virtually any global public good embodies interrelated spheres of influence on multiple scales. The nature of the good itself, spatial limits, and human-made borders regularly create local barriers, resulting in production externalities on national, regional, and communal scales. This paper is about voluntary contributions to a public good with local and global dimensions through positive spillovers.

Protecting the global climate probably manifests the timeliest and most acknowledged global level social dilemma with local dimensions. While the increase of greenhouse gases in the atmosphere has created a dramatic contingency of changing living conditions on a global level, manufacturing and transportation technologies releasing air pollutants have several locally determined consequences including fine-particulate air pollution and traffic congestion problems, among others. Amid the myriad of other global goods with local externalities, some particularly noteworthy ones are locally directed foreign aid to reduce global terrorism, regionally and universally significant university systems, and the preservation of natural wildlife habitats.

The study of pure public goods (Samuelson, 1954) and other single scale social dilemmas has long been in the foreground of behavioral economics.

[1] The opening sentences naturally pay tribute to Lennon (1971) who introduced the notion of a global public good earlier - and perhaps more vividly - than any research economist has done since. Luckily, we are all economists.

Within the standard approach, positive contributions by individual decision makers are automatically available to all participants. In a typical public good with linear payoff function, the lowest possible individual contribution is the dominant strategy (Isaac et al., 1984). The stylized facts originating from single dimensional public good experiments are extremely robust (Ledyard, 1995). The voluntary provision of a public good is socially suboptimal. Positive contributions are, however, frequent but typically decline with repetitions from the initial level toward the equilibrium. Positive contributions have been observed after as many as 50 periods (Gächter et al., 2008).

It appears that the observed level of cooperativeness is not tied to a boundary condition. Isaac and Walker (1991) refute the conjecture that contributions are affected merely by shifting the location of the equilibrium to an interior condition of the set of feasible contributions. Subsequent studies with interior dominant and efficient strategies have found no systematic evidence for this conjecture (Laury and Holt, 2008).

The question of how to overcome the experimentally confirmed failure of voluntary contribution mechanisms has emerged as one of the most fundamental issues in the social sciences. Notable theoretical refinements, including the Folk Theorems (Aumann, 1981; Axelrod, 1984) for repetitive interaction and elements of uncertainty questioning the common knowledge of rationality (Kreps et al., 1982; Kreps and Wilson, 1982), offer an equilibrium justification for positive contributions stabilized through future dealings. Among the vast body of institutional solutions, enforceable commitments (Schelling, 1960), self-governed sanction mechanisms (Yamagishi, 1986) intertwined with communication(Ostrom et al., 1992), reputation networks (Nowak and Sigmund, 1998), leadership structures (Güth et al., 2007), and ostracism (Maier-

Rigaud et al., Forthcoming) may serve as proximate mechanisms to overcome the problem of free riding.

At the same time, numerous structural and motivational approaches have been suggested to investigate the impact of intergroup competition on human cooperation (Bornstein and Ben-Yossef, 1994). When payoffs are contingent upon the relative ranking or absolute difference between the competing groups and the reward is shared equally among the in-group members, the individual incentive to cooperate becomes congruent with the group's interest. Without imposing payoff sharing norms on a group, the self-interested strategy, however, fails to make any contribution. Various laboratory (Bornstein and Erev, 1994) and field (Erev et al., 1993) experiments on intergroup competition nevertheless reveal increased in-group cooperation. These behavioral observations, attesting to the enhanced individual willingness to sacrifice own resources to a group cause, belong to most robust results in social psychology (Bornstein, 2003).

The study of voluntary contribution mechanisms, including proposed structural and motivational solutions to the tragedy of the commons, has thus far largely ignored the potential of joint production benefits on multiple scales. A notable exception are Cornes and Sandler (1984) and their seminal theoretical contribution toward understanding the nature of impure public goods. Their analysis is diversified to include interdependent private and public good characteristics. The original idea has later been extended to the warm-glow of giving as discussed in Andreoni (1990).

The simultaneity of local and global beneficiaries in public good provision has been recognized only in a few behavioral inquiries. Blackwell and Mckee (2003) and Fellner and Lünser (2008) both conduct experiments with exclusive local and global group accounts whereby contributions to a local group have no global-scale consequences. The innate bias toward the local group is tacitly confirmed. Furthermore, both studies find that the relative returns of the two public goods varying in excludability have a significant impact on voluntary contribution. Buchan et al. (2009) suggest that the individual propensity to contribute in a multilevel social dilemma is correlated with global attitudes measured by the Globalization Index survey.

In this paper, we introduce and experimentally implement a novel multilevel social dilemma model based on a positive interdependency between local and global beneficiaries. Within the game paradigm, individual provision decisions are repetitively realized. Thus, conditional cooperation and implicit punishment are enabled through appropriate feedback between periods but not explicitly inspired or experimentally demanded by any institutional arrangements. To capture the nestedness of global and local level stakeholders in our design, group identities are not only inspired by labeling (the minimal group paradigm) but also (i.) by stronger positive payoff interdependencies within rather than between local groups and (ii.) by symmetry within local groups and asymmetry across local groups.

The advantage of our design is that the paradigmatic conflict between individual optimality and collective efficiency is transferred to a situation where individual opportunism can be questioned both by subgroup and overall efficiency concerns. Saliently induced local group identity (Tajfel, 1982), a greater prospect of reciprocity (Fehr and Gächter, 2000), and conditional cooperation (Fischbacher and Gächter, Forthcoming) within the local group all predict high resource allocations enhancing local efficiency. At the same time, voluntary contributions toward global efficiency are inspired by positive spillovers across groups, transforming group interdependency from competition to cooperation. Inter alia, Anderson et al. (1998) indicate that altruistically motivated players increase their contributions to the common good when benefits are shared by a larger group of recipients. This result encourages the prediction that altruistic players act upon global efficiency.

In comparison to other social dilemma games like, for instance, the frequently used linear public good game, we retain that all players have a dominant strategy regardless of other players' behavior. Both local and global efficiency require individually costly choices. However, all benchmark contribution levels are implemented in the interior of the feasible choice set. That is, participants may deviate from each benchmark by choosing either a lower or higher provision. In our view, this has the advantage that pure noise in decision making is equally possible below and above the benchmark level.

The necessary nonlinearity is reduced to choice costs, determined by simple quadratic cost functions. The spillovers from an individual choice are determined by linear functions, similar to linear public good games. While a multilevel game with positive spillovers may have a great number of parameters, individual and group characteristics in our experiment are restricted to include three dimensions. Each player is defined by one cost parameter and one local and global productivity parameter. Since the local group identity is inspired by in-group symmetry, we experimentally examine a social dilemma game determined by six parameters, two cost parameters, and two different sets of local and global parameters. We refer to this game as the Spillover Game (SG).

The remainder of the paper is organized as follows. In section 2, we formally introduce and analyze the characteristics of the Spillover Game, focusing on the experimental implementation. Section 3 describes the experimental protocol. After presenting and analyzing the data in section 4, we conclude in section 5 with a brief discussion on our results.

2. Spillover Game

Let $N = \{1, ..., n\}$ with $n \geq 2$ denote the set of players $h = 1, 2, \ldots n$, which is partitioned into two subgroups $I = \{i_1, \ldots, i_{m_i}\}$ and $J = \{j_1, \ldots, j_{m_j}\}$ with $m_i, m_j \geq 2$ and $m_i + m_j = n$. We use notation $k \in N$ for any player as well as $i \in I$ and $j \in J$ when referring to players in a certain subgroup.

Player h's strategy is her production amount $c_h (\geq 0)$. Producing c_h costs

$$C_h(c_h) = \frac{c_h^2}{d_h} \text{ with } d_h > 0 \text{ for all } h \in N. \quad (1)$$

Player h gains linearly from the production amounts of all players according to a payoff function

$$U_h = \sum_{k \in N} \alpha_k^h c_h - C_h(c_h) \text{ with } \alpha_k^h > 0 \text{ for all } h \in N. \quad (2)$$

More specifically, we speak of a Spillover Game (SG) when for all $h \in N$

$$\alpha_h^h > \alpha_i^h > \alpha_j^h > 0 \text{ if } h \in I, h \neq j;$$

$$\alpha_h^h > \alpha_j^h > \alpha_i^h > 0 \text{ if } h \in J, h \neq i.$$

The first inequalities capture the regularity that players profit most from their own contributions; the second inequalities express the greater spillover toward local subgroup members. The last inequalities render individual contributions globally effective.

2.1. Experimental implementation

Our Spillover Game experiment is based on parameters

$$\alpha_h^h = 1 \text{ for all } h \in N$$

$$\left.\begin{array}{l} \alpha_i^h = \bar{\alpha}^h \text{ for all } h \in I \\ \alpha_j^h = \underline{\alpha}^h \text{ for all } h \in J \end{array}\right\} \text{ with } 1 > \bar{\alpha}^h > \underline{\alpha}^h > 0 \text{ for all } i \in I,$$

$$\left.\begin{array}{l} \alpha_j^h = \bar{\alpha}^h \text{ for all } h \in J \\ \alpha_i^h = \underline{\alpha}^h \text{ for all } h \in I \end{array}\right\} \text{ with } 1 > \bar{\alpha}^h > \underline{\alpha}^h > 0 \text{ for all } j \in J.$$

Thus, each player $h \in N$ is characterized by her attributes

$$(d_h, \bar{\alpha}^h, \underline{\alpha}^h)$$

specifying her cost type d_h and how strongly she affects members of her in-group ($\bar{\alpha}^h$) and her out-group ($\underline{\alpha}^h$). In this setup, opportunism in the sense that player $h \in N$ maximizes her own payoff U_h obviously implies

$$(0)\ c_h^* = \frac{d_h}{2}. \tag{3}$$

If a player $h \in N$, however, only cares for the total payoff of her in-group and not for her out-group members, she would maximize

$$[1 + (m_i - 1)\bar{\alpha}^h]c_h - C_h(c_h) \text{ if } h \in I,$$
$$[1 + (m_j - 1)\bar{\alpha}^h]c_h - C_h(c_h) \text{ if } h \in J.$$

Local efficiency thus predicts production amounts

$$(LE)\mathrm{c}_{\mathrm{h}}^{+} = \begin{cases} \frac{[1+(m_i-1)\bar{\alpha}^h]\mathrm{d}_\mathrm{h}}{2} & \text{for } h \in \mathrm{I} \\ \frac{[1+(m_j-1)\bar{\alpha}^h]\mathrm{d}_\mathrm{h}}{2} & \text{for } h \in \mathrm{J}. \end{cases}$$

Global efficiency does not restrict efficiency concerns to one's in-group but suggests to consider all spillovers by maximizing

$$[1 + (m_i - 1)\bar{\alpha}^h + m_j \underline{\alpha}^h]\mathrm{c}_\mathrm{h} - C_h(c_h) \text{ if } h \in I$$
$$[1 + (m_j - 1)\bar{\alpha}^h + m_i \underline{\alpha}^h]\mathrm{c}_\mathrm{h} - C_h(c_h) \text{ if } h \in J.$$

The prediction by global efficiency is thus

$$(GE)\mathrm{c}_{\mathrm{h}}^{\oplus} = \begin{cases} \frac{[1+(m_i-1)\bar{\alpha}^h+m_j\underline{\alpha}^h]\mathrm{d}_\mathrm{h}}{2} & \text{for } h \in I \\ \frac{[1+(m_j-1)\bar{\alpha}^h+m_i\underline{\alpha}^h]\mathrm{d}_\mathrm{h}}{2} & \text{for } h \in J. \end{cases}$$

In the experiment we will try to strengthen group identity by symmetry within the in-group by imposing

$d_i = 4$, $\alpha_i^h = \bar{\alpha}^I$ and $\alpha_j^h = \underline{\alpha}^I$ such that $1 > \bar{\alpha}^I > \underline{\alpha}^I > 0$ for all $h \in I$,

$d_j = 6$, $\alpha_j^h = \bar{\alpha}^J$ and $\alpha_i^h = \underline{\alpha}^J$ such that $1 > \bar{\alpha}^J > \underline{\alpha}^J > 0$ for all $j \in J$.

When setting $m_i = 3 = m_j$ one, however, still derives the same efficiency benchmarks for both groups by imposing

(LE') $(1 + 2\bar{\alpha}^I)4 = (1 + 2\bar{\alpha}^J)6$ for local efficiency (LE) and

(GE') $(1 + 2\bar{\alpha}^I + 3\underline{\alpha}^I)4 = (1 + 2\bar{\alpha}^J + 3\underline{\alpha}^J)6$ for global efficiency (GE).

Experimental treatments are implemented in a way that in treatment (LEGE) parameters $\bar{\alpha}^I, \underline{\alpha}^I, \bar{\alpha}^J, \underline{\alpha}^J$ are such that both (LE) and (GE) are satisfied, whereas in the other two treatments (LE) and (GE) only one of the two equalities holds. Clearly, opportunism predicts higher production amounts in subgroup J than in subgroup I due to $d_j > d_i$. Members of group I have higher production costs. Note that producing less than is optimal would reveal spitefulness. Members of group I may produce less than $\frac{d_i}{2}$ simply because they consider the game unfair. We, however, expect strong other-regarding concerns at least toward the members of the in-group whose solidarity is inspired by (i.) labeling in the sense of the minimal group paradigm, (ii.) stronger positive spillovers within than across groups, and (iii.) the symmetry of players in the same subgroup.

3. Experimental Procedure

The main characteristic of our experimental design is the interdependence of voluntary contributions between asymmetric groups, reflecting the nature of global-scale interaction. In our experiment, six subjects form a global group which is partitioned into two local groups of equal size. In the instructions, we refer to these distinct but interdependent groups as X and Y and to the subjects in a corresponding group as X-players and Y-players, respectively. Individual provision decisions, c_h, are restricted to integers ranging from 0 to 10.

Individual choices are collected under three different treatments varying in production efficiency between local and global groups. We compare situations in which X and Y are equally efficient with a situation in which either group X or Y is more efficient in local or global-scale production. Optimal opportunistic, local, and global contribution amounts do not change between treatments. Similarly, cost parameters used to inspire local group identity remain fixed across treatments. Table 1 provides a summary of the applied costs and spillovers in respective treatments. When analyzing the experimental data in section 4, we refer to a label assigned to each treatment or drop the treatment labels entirely when analyzing data pooled across all treatments.

The experiment was implemented applying both stranger and partner design equivalent to definitions by Andreoni (1988). All participants played 15 repetitive periods under both matching protocols. At the end of each experimental session, one 15 period block of cumulative earnings was randomly chosen to determine the final payoff from the decision task. The random draw was performed by one of the participants with a coin flip. The order of matching protocols was counterbalanced across sessions to control for possible sequence effects. Participants received feedback at the end of each period regarding the local and global-scale spillovers. We ruled out any kind of reputation formation within and across subgroups by reshuffling the order of individual contributions displayed after each period. The anonymity of all players was guaranteed throughout the experiment.

The experiment was conducted at the laboratory of the Max Planck Institute of Economics in Jena (Germany). The experiment was programmed and run using the z-Tree (Fischbacher, 2007). A total number of 180 subjects in six sessions participated in the experiment. The 109 female and 71 male subjects were mainly undergraduate students from the Friedrich-Schiller University of Jena, studying a range of different disciplines. Upon arriving at the laboratory, participants were randomly assigned to their cubicles preventing communication and visual interaction. They were given detailed instructions and a number of control questions on paper. Instructions were read aloud including the examples. The experiment began after participants had answered all control questions correctly. After the experiment participants were paid privately in cash according to their performance. On average, the experiment lasted 90 minutes. Earnings per participant ranged from 8 to 26 euros with an average of 15 euros.

Table 1: Experimental treatments with their spillover parameters

Treatment		Cost parameter	Ingroup spillover	Outgroup spillover
LEGE	Type-X	4	0.6	0.3
	Type-Y	6	0.4	0.25
LE	Type-X	4	0.6	0.3
	Type-Y	6	0.4	0.3
GE	Type-X	4	0.5	0.4
	Type-Y	6	0.5	0.2

4. Results

To characterize the nature of voluntary cooperation in a nested social dilemma under positive group interdependencies, we organize the discussion of our results as follows. To begin with, we describe the observed initial inclination toward the in-group optimum and the ensuing steady decline toward the opportunistic benchmark. Thereafter, the remarkable robustness of observed behavior is confirmed. Finally, we demonstrate which behavioral determinants guide individual contribution decisions. The main analysis is conducted by pooling observations over all treatments. The implications of unobserved sequence and treatment effects are subsequently discussed.

4.1. The nature of cooperation in the Spillover Game

Figure 1 sets the stage for our analysis, depicting the temporal pattern of average contributions and conveying an unequivocal message. Observed provision rates occur on average always between the local efficiency and the opportunistic benchmark. This clearly challenges the explanation of voluntary cooperation by decision errors (Palfrey and Prisbrey, 1997) as contributions below the opportunistic benchmark level are rare even for X-players who, due to their cost handicap, might be spiteful. More concretely, the finding stresses the substance of local level beneficiaries in the provision of a public good with multiple scales.

Result 1 The local efficiency benchmark serves as an upper boundary for average contributions.

Figure 1 about here

Despite the fact that all derived benchmark predictions are located in the interior of the feasible choice set, they differ according to the type of player. Y-players deviate more markedly from the local efficiency due to its relative location in the upper half of the decision space, although the production efficiencies remain constant across player types and benchmark predictions. In other words, the location of the benchmark relative to the individual choice set affects contributions. This observation is congruent with earlier evidence from nonlinear public good experiments with a single group (Isaac and Walker, 1998).

Result 2 The steady decline in contributions unfolds independently of player type or matching protocol.

Figure 1 creates a qualitative impression of declining contribution rates. The declining trend is indeed confirmed in table 2, reporting Pearson correlation coefficients between periods and their respective average contributions for each independent observation. On the aggregate level, the steady decline in positive contributions prototypical for voluntary contribution mechanisms is observed irrespective of matching protocol or player type.

Result 3 Partners matching yields higher contribution levels than strangers matching in the Spillover Game.

Table 2 provides an overview of individual contributions and earnings averaged across all periods. The difference between fixed group interaction and randomly repeated single-shot iterations is tested by comparing a set of observations within subject under both matching protocols. We reject the null hypothesis of no difference between partner and stranger design (Wilcoxon signed-rank test; Z=-3.267, n=18, p=0.001). As a result of this behavioral pattern, the local efficiency benchmark is more closely approximated by stable groups than randomly changing groups.

How well do the theoretical predictions organize observed data? Table 3 reports average contributions in the first and last period of iterative inter-

Table 2: Overview of average contributions, time trend and treatment differences

	Stranger			Partner		
	Average Cont.	Average Earnings	Time trend	Average Cont.	Average Earnings	Time trend
Type X	2.80	6.57	-.22**	3.06	6.99	-.27**
	(.30)	(1.02)		(.76)	(1.27)	
Type Y	3.92	7.13	-.19**	4.25	7.43	-.21**
	(.15)	(0.59)		(0.73)	(0.83)	
Treatment difference	N.A	N.A	N.A	3.357 (df=2) p=0.187	3.520 (df=2) p=0.172	2.468 (df=2) p=0.291

Average contributions and earnings in ECUs, standard deviation in parenthesis. Time trend over all periods is indicated by the Pearson correlation coefficient. Treatment differences are tested applying Kruskall-Wallis (2-sided) test. Data are analyzed at the group level to account for the independence of observations. **Significant at 1%; *Significant at 5%; +Significant at 10%.

action. The former empirical outcome is tested against the local efficiency and the latter against the opportunistic optimality benchmark. The downward slope in voluntary provisions is corroborated by comparing the average rates in the first and last period. Despite the fact that a large majority of individual contributions lie in a range between local efficiency and individual opportunism, these predictions hardly provide accurate benchmarks to aggregate behavior. The null hypothesis of no difference between theoretical benchmark and observed behavior in the respective periods of interaction is rejected except for two cases (table 3). At the same time, separate test statistics for X- and Y-players strengthen the observation that the predictions' location relative to the individual choice set affects its prognostic power.

Table 3: The comparison of observed and predicted average outcomes in the first and last round of iterative interaction

	Average contribution (Round 1) - Local prediction		Average contribution (Round 15) - Opportunistic prediction	
	Stranger	Partner	Stranger	Partner
Type X	3.26 (.80)	3.50 (.92)	2.42 (.24)	2.54 (.72)
	(n=6)	(n=18)	(n=6)	(n=18)
	p=0.075	p=0.046	p=0.028	p=0.003
Type Y	4.49 (.45)	4.83 (1.20)	3.16 (.27)	3.54 (.80)
	(n=6)	(n=18)	(n=6)	(n=18)
	p=0.028	p=0.003	p=0.141	p=0.006

Average contributions (and standard deviations) in the first and last round. Deviations from opportunistic and local efficiency predictions are tested applying Wilcoxon signed rank test (2-sided) against the null hypothesis that no difference exists. All data are analysed at the group level to account for the independence of observations.

4.2. The robustness of results

Until now, our behavioral analysis has been based on aggregated data irrespective of the sequence of play or experimental treatment. In this section, we discuss the robustness of our preceding findings considering these issues.

Result 4 The observed behavioral patterns in the Spillover Game are robust to the sequence of interaction and changes in monetary incentives at the margin.

The distribution of voluntary contribution decisions proves to be robust to past decisions. We perform the Mann-Whitney (exact) test against the null hypothesis that both mean and slope are equally distributed under the respective matching protocol between a sequence without previous interaction and a subsequent sequence following the first 15 periods of play. Test statistics for the stranger (Z=-1.964, n=6, p=0.100) and partner (Z=-1.008, n=18, p=0.360) design singly do not support the rejection of the null hypothesis.[2] As a result, participants who have experienced related interpersonal encounters do not behave differently than those without such an experience in the Spillover Game. The behavioral pattern of public good provision, ranging from local efficiency to individual opportunism, is robust to order effects.

Changes in the marginal per capita rate of return (MPCR) are considered to have a significant effect on the willingness to cooperate in public good games. Similarly, changes in the overall group productivity derived by multiplying the MPCR with the number of players regularly induce measurable behavioral changes in individual public good provision.

We examine the influence of varying payoff parameters in the Spillover Game by comparing the behavioral response under three different treatments. The general result of varying spillover parameters is suggested in the bottom half of table 2. The Kruskall-Wallis test for the equality of population medians between the three treatments does not allow us to reject the null hypothesis that no differences exist between treatments. Examining the differences on a more subtle level, we recognize that the greater out-group spillovers and increased global efficiency between treatments LEGE and GE are likely to cause a more significant effect on Y-players due to the change that is restricted to their productivity. Despite performing a more specific pairwise test to examine the behavioral reaction of Y-players (Mann-Whitney exact

[2]The Kolmogorov-Smirnov two sample (exact) test that is sensitive to differences in both location and shape of the empirical cumulative distribution functions yields similar results relative to the conceivable sequence effect. All test specifications tried yield p-values of 0.1 or higher.

test; Z=-1.210, n=18, p=0.234), we do not find evidence that suggests a significant response to changes in spillover parameters. A similar result holds irrespective of the player type when testing for possible differences between treatments GE and LE. The robustness of aggregated individual responses to the changes in coefficients reflects robust behavioral patterns in the Spillover Game.

4.3. Determinants of contributions

In this section, we investigate the determinants of observed behavior. We estimate three different multilevel regression models under both matching protocols, as documented in table 4.

Result 5 The temporal pattern of contributions is a result of imperfect conditional cooperation that prioritizes local level feedback over global one.

Model (1) serves as a starting point of our analysis, including only production spillovers received from other in-group members in a period. A strong inclination toward realized outcomes of preceding interaction is expected. Consequently, we find that subjects reveal a significant tendency to conditional cooperation.

Our results provide strong econometric evidence that conditional cooperation is restricted to in-group interaction. Models 2 and 3 include both in- and out-group spillovers from the preceding period. However, only in-group outcomes prove to be significant. Furthermore, it should be noted that in- and out-group spillover flows are only modestly correlated ($\rho = .208$). In

Table 4: Mixed effect regression coefficients on the determinants of contributions

	Dependent variable					
	Contribution			Contibution		
	Stranger			Partner		
Fixed Effects	(1.1)	(1.2)	(1.3)	(2.1)	(2.2)	(2.3)
In.group$_{t-1}$	.181***	.188***	.124***	.360***	.328***	.263***
	(.022)	(.037)	(.023)	(.026)	(.039)	(.027)
Out.group$_{t-1}$		.072	.042		.052	-.007
		(.045)	(.031)		(.050)	(.037)
In.g$_{t-1}$ x period		-.009**			-.008**	
		(.004)			(.004)	
Out.g$_{t-1}$ x period		-.005			-.008*	
		(.005)			(.005)	
Period			-.041***			-.055***
			(.005)			(.006)
Male			.147			.259
			(.152)			(.157)
Region			-.117			.120
			(.208)			(.214)
Constant	2.556***	2.682***	2.931***	2.247***	2.633***	2.958***
	(.101)	(.134)	(.167)	(.118)	(.174)	(.216)
Random Effects						
Subject (Sd)	.953	.963	.962	.966	.974	.956
	(.054)	(.055)	(.055)	(.056)	(.062)	(.062)
Group (Sd)					.199	.244
					(.164)	(.144)
Observations	2520	2520	2520	2520	2520	2520
	(180)	(180)	(180)	(180)	(180) (30)	(180) (30)
Log-likelihood	-3738.8	-3709.5	-3707.9	-3971.0	-3937.7	-3930.2

Mixed-effect regression coeffiecients, specifications vary with respect to included random effects. Robust standard errors in parenthesis. **Significant at 1%; *Significant at 5%; +Significant at 10%.

other words, results suggest that the observed decline in contributions is due to imperfect conditional cooperation.

Among other explanatory variables, model (3) includes 'period', reconfirming the significant decline in contributions over time. More importantly, we have built into a parallel model a time-dependent interaction term with in- and out-group spillovers. Model 2 reveals a time trend in the relative importance of in-group spillovers. Negative interaction between period and received spillovers indicates an attenuating impact of within-group conditioning in the decision process over time. In other words, a vicious circle of declining contributions and lessening impact of feedback is created whereby the aggregate provision of a public good is driven toward the opportunistic prediction.

5. Conclusions

This paper has examined the characteristics of human behavior in a nested social dilemma game with positive interdependencies. With the help of the Spillover Game, introduced in section 2, the theoretical analysis of voluntary cooperation mechanisms is extended to intergroup cooperation, largely neglected in the standard models of public good provision. Distinguishing between opportunism and local and global efficiency, we have experimentally demonstrated the importance of in-group beneficiaries.

We find that the observed behavior in a nested intergroup social dilemma game is significantly determined by imperfect conditional cooperation in the sense of mainly relying on local level feedback. At the same time, the relative importance of received spillovers attenuates over time. The dynamics of voluntary cooperation in a nested collective action problem with positive interdependencies can be understood by the coexistence of conditional cooperation and opportunistic preferences.

The Spillover Game and its experimental implementation are designed to explore the nature of human behavior in nested action situations where externalities exist at multiple scales. Experimental designs such as the one presented in this paper may contribute to our understanding of voluntary cooperation within and between asymmetric groups that are inherent in human social organization. We are confident that the study of nested social dilemmas between groups yields relevant insights to decision-making about the incentives to contribute to a common cause when there are potential benefits at multiple scales. This opens up a perspective for new research designs that allow studying governance and communication structures within and between positively interdependent groups.

The primary nature of local beneficiaries stresses the importance of close-knit solidarity in public good provision, suggesting that the emergence of social norms is predominantly supported through local level interaction. When relating our findings to the policy analysis of collective action problems, the importance of local scale interaction and inclination toward the in-group is stressed. Results provide empirical evidence supporting the potential benefits of building a strong local commitment to encourage the provision of public goods with positive externalities (Ostrom, 2009). We have to acknowledge the strong local level emphasis of conditional cooperation when designing mechanisms and determining effective units of governance to promote resource conservation and a sustainable provision of public goods.

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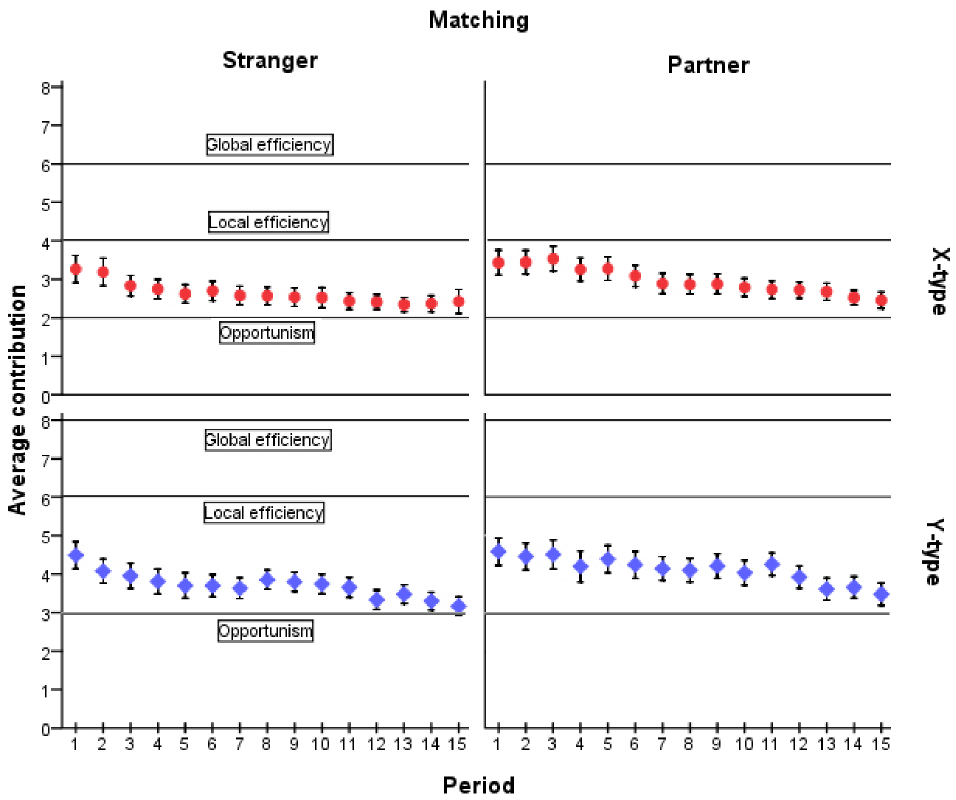

Figure 1: Average contributions to the public good according to the player type over 15 rounds of play in groups with stranger and partner matching.